PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventor: GEORGE WILLIAM DANIELS

841,951

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International Classification: —F25b.

COMPLETE SPECIFICATION

Improvements in or relating to Heat-Exchangers

ERRATA

SPECIFICATION No. 841,951

Page 2, line 87, *after* "used" *insert* "by"
Page 2, line 104, *for* "interconnected" *read* "inter-connected"
Page 3, line 75, *for* "part" *read* "apart"
Page 3, line 112, *for* "tubes" *read* "tube"
Page 4, line 30, *for* "heat-exchangers" *read* "heat-exchanger"
Page 4, line 61, *for* "comprise" *read* "comprises"
Page 5, line 12, *for* "fromed" *read* "formed"
Page 5, line 47, *for* "deschibed" *read* "described"
Page 5, line 51, *for* "conneceted" *read* "connected"

THE PATENT OFFICE
6th June 1967

of adjacent edges of the side plates, the headers and tubes constituting a flow path for one heat-exchange fluid, each header including a channel-section header member, the heat-exchange tubes being entered into holes in the webs of the channel section header members, the flanges of each header member being held between the side plates, and there being an inlet and outlet to the space between the plates which space constitutes a flow path for another heat-exchange fluid.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made to the accompanying drawings, in which: —

Figure 1 is a sectional elevation of a heat-exchanger,

Figure 2 is a cross-section along the line II—II of Figure 1,

Figure 3 is a longitudinal section along the line III—III of Figure 1,

Figure 4 is a sectional view of a modifica-

channel-section side members 6 and 7, and two channel-section header members 8 and 9 forming part of the headers 4 and 5 respectively. The flanges of the channel-section side members 6 and 7 are formed with holes 10 for registering with corresponding holes 11 formed in marginal portions of the side plates 1 and 2, the side members 6 and 7 and the side plates 1 and 2 being secured together by bolts 12 passing through the registering holes 10 and 11. The web of the side member 6 is formed with two apertures 13 and 14 which are located one near each end of the member, two flanged pipes 15 and 16 being connected to the member 6 in such a way that each pipe communicates with the space between the plates 1 and 2 through a respective one of each of the apertures 13 and 14, thereby constituting an inlet (16) and an outlet (15) for the other heat-exchange fluid.

The top and bottom headers 4 and 5 are of identical construction, and it will suffice to

[*Price*

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International Classification:—F25b.

COMPLETE SPECIFICATION

Improvements in or relating to Heat-Exchangers

We, XFLO HEAT EXCHANGERS LIMITED, a British company, of 139, Temple Chambers, Temple Avenue, London, E.C.4, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to heat-exchangers and is concerned with an improved heat-exchanger of simple construction.

According to the invention there is provided a heat-exchanger comprising one or more inter-connected heat-exchange elements, wherein the element or battery of elements comprises two flat, rectangular side plates, spaced apart from one another, and heat-exchange tubes extending between the plates from a first header, or battery of headers, disposed along one pair of adjacent edges of the side plates, to a second header, or battery of headers, disposed along the opposite pair of adjacent edges of the side plates, the headers and tubes constituting a flow path for one heat-exchange fluid, each header including a channel-section header member, the heat-exchange tubes being entered into holes in the webs of the channel section header members, the flanges of each header member being held between the side plates, and there being an inlet and outlet to the space between the plates which space constitutes a flow path for another heat-exchange fluid.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made to the accompanying drawings, in which:—

Figure 1 is a sectional elevation of a heat-exchanger,

Figure 2 is a cross-section along the line II—II of Figure 1,

Figure 3 is a longitudinal section along the line III—III of Figure 1,

Figure 4 is a sectional view of a modification of part of the heat-exchanger shown in Figures 1 to 3,

Figure 5 is a view similar to Figure 4, but showing two of the parts illustrated in Figure 4 in abutting relationship, and

Figure 6 is a fragmentary view similar to Figure 3, but showing a modification of part of the heat-exchanger.

Referring now to Figures 1 to 3 of the drawings, there is shown a heat-exchanger comprising two rectangular side plates 1 and 2 which are spaced apart from one another. Straight tubes 3 extend between the plates 1 and 2 as between a top header 4 and a bottom header 5, the headers and tubes constituting the flow path for one heat-exchange fluid, and the space between the tubes and the side plates constituting the flow path for the other heat-exchange fluid.

The side plates 1 and 2 are, for example, made of ¼" thick mild steel, and are held in spaced parallel relation by means of two channel-section side members 6 and 7, and two channel-section header members 8 and 9 forming part of the headers 4 and 5 respectively. The flanges of the channel-section side members 6 and 7 are formed with holes 10 for registering with corresponding holes 11 formed in marginal portions of the side plates 1 and 2, the side members 6 and 7 and the side plates 1 and 2 being secured together by bolts 12 passing through the registering holes 10 and 11. The web of the side member 6 is formed with two apertures 13 and 14 which are located one near each end of the member, two flanged pipes 15 and 16 being connected to the member 6 in such a way that each pipe communicates with the space between the plates 1 and 2 through a respective one of each of the apertures 13 and 14, thereby constituting an inlet (16) and an outlet (15) for the other heat-exchange fluid.

The top and bottom headers 4 and 5 are of identical construction, and it will suffice to

[*Price*

describe only one such header in detail. The header 4 consists, for example, of a drawn mild steel pipe 17 of greater length than the breadth of the side plates 1 and 2, the pipe 17 having a flanged connection 18 at one end and being sealed as at 19 at the other end. An axially extending cut-out 20 is formed in the pipe 17 at its end the cut-out 20 extending for substantially the breadth of the side plates 1 and 2, and the channel-section header member 8 is disposed around the cut-out 20 with the flanges of the member 8 secured to the wall of the pipe 17. Bridge-shaped end plates (not shown) are secured one at each end of the member 8 for ensuring a fluid-tight connection between the member 8 and the pipe 17. The flanges of the channel-section header member 8 are formed with registering holes 21, and tubes 22 extend one between each hole 21 of one flange to a registering hole 21 of the other flange. The holes 21 are formed to register with corresponding holes 23 formed in marginal end portions of the side plates 1 and 2, and the header 4 is secured to the side plates 1 and 2 by bolts 24 passing through the registering holes 21 and 23 and the tubes 22. The bottom header 5 is identical with the top header 4, and is formed from a tube 25 secured to the channel-section header member 9, the header 5 being secured to the side plates 1 and 2 in the same manner as the header 4 by bolts 24 passing through registering holes 21 and 23, and tubes 22.

The web of each of the channel-section header members 8 and 9 is formed with a plurality of staggered apertures 26, into each of which is entered a respective one of the heat-exchange tubes 3, the tubes 3 being, for example, drawn mild steel tubes which are welded into position. The tubes 3 are entered at each end into one of the header members 8 and 9, and extend between the side plates 1 and 2, the headers constituting an inlet (5) and an outlet (4) for said one heat-exchange fluid.

In order to prevent the side plates 1 and 2 from buckling inwardly or outwardly under the influence of heat and/or pressure, registering holes 27 are formed in the plates 1 and 2. A spacing tube 28 extends between each pair of registering holes 27, and a bolt 29 passes through each tube 38 and its associated holes 27, the heads of the bolts 29 and the nuts thereof bearing against the plates 1 and 2 by means of washers 30 so as to ensure that heat-exchange fluid is not able to escape past the bolts 29. The holes 27 in the side plates 1 and 2 are arranged in vertical rows, and because of the spacing tubes 28, the heat-exchange tubes 3 have to be arranged in groups, as shown in Figures 1 and 2.

The space between the heat-exchange tubes 3 and the side plates 1 and 2 is sub-divided by a plurality of horizontal baffles 31, staggered so as to provide a number of passes for the other heat-exchange fluid. Each baffle 31 is of substantially channel-shape but the angles between the web and the flanges are slightly more than 90°, so that when the side plates are brought together the flanges are displaced to a position where they are perpendicular to the web, the baffles being thereby held firmly in position. Each baffle 31 extends for a major portion of the breadth of the side plates 1 and 2, and is apertured to receive the heat-exchange tubes 3 which pass through the baffles.

The headers 4 and 5 are arranged with their inlet or outlet at one side of the exchanger, so that the exchanger has but one tube pass. However, by arranging the headers with the inlets and outlets at opposite sides of the exchanger, it is possible to provide a plurality of tube passes by positioning appropriate baffles in the headers.

The heat-exchanger described may be used itself, or may constitute one element of a composite heat-exchanger which consists of a plurality of such elements disposed side-by-side and appropriately inter-connected to form a battery. The elements are connected together side-by-side by means of long bolts passing through the spacing tubes 28 of each element, the composite exchanger then having but one side plate 1 at one side of the composite exchanger and another side plate 2 at the other side of the composite exchanger, and the flanges of the baffles 31 of one heat-exchange element abutting against the flanges of the baffles 31 of another heat-exchange element.

Where a number of the heat-exchange elements are interconnected to form a battery, as just indicated, there may be some difficulty in correctly aligning the baffles 31, and, in this case, it is preferable to use baffles such as that shown in Figure 4. The baffle shown in Figure 4 consists of a plate 32 corresponding to the web of the baffle 31, having a member 33 of rubber, or like resilient synthetic plastic material at each end thereof. Each of the members 33 is substantially crescent-shaped in cross-section, and has a divided rib 34 on its convex side, the plate 32 being fitted into the division of the rib 34. When two of the baffles shown in Figure 4 abut against one another the concave surfaces become substantially flattened, as shown in Figure 5, thereby providing a fluid-tight seal between the spaces above and below the baffle.

It will be appreciated that many modifications of the heat-exchanger are possible, including increasing the external or internal surface area of the tubes 3 by finning. Where the exchanger is to be subjected to high internal pressures, it is possible to strengthen the side plates 1 and 2 by means of external spiders held in position by the bolts 29 passing through the spacing tubes 28. Also, it is

possible to make the heat-exchanger of Figs. 1 to 3 in annular form where it is to be subjected to high internal pressures, the side plates being bent to enclose an annular space within which the tubes are disposed and the edges of the side plates being joined up, so that each side plate forms a tube. The headers and the upper and lower channel-section header members, are likewise made annular and the inlet and outlet to the upper and lower headers are repositioned to extend axially of the heat exchanger. The inlet and outlet for the other heat exchange fluid extend radially from the side walls of the heat exchanger.

As a further modification, the headers 4 and 5 can include detachable covers so arranged as to be readily removable and to provide easy access to the tubes, whereby cleaning of the tubes is facilitated. Referring now to Figure 6 of the drawings, there is shown a cross-section through a header having a detachable cover, the remainder of the heat-exchanger being substantially the same as that shown in Figures 1 to 3. As before, the exchanger has side plates 1 and 2 and heat-exchange tubes 3. The ends of the heat-exchange tubes 3 are welded into a channel-section header member 35. The flanges of the member 35 protrude beyond the ends of the side plates 1 and 2, and a plate 36 rests on the ends of the flanges of the member 35, the plate 36 being formed with recesses 37 to accommodate the ends of the flanges of the member 35. The plate 36 is formed with a plurality of central apertures 38 through each of which passes a long bolt 39, the bolt 39 passing through one of the tubes 3 and being secured by a nut outside a plate 36 forming part of the other header (not shown.

While not shown in the drawings for the sake of clarity, it is to be appreciated that packing material is provided between the side plates 1 and 2, and the channel-section header members and side members, and between the plates 36 and the flanges of the header members 35 where necessary.

Due to its construction, the heat-exchanger lends itself to economical and mass production, and for a given duty takes up less floor or packing space than an equivalent conventional heat-exchanger. Also, the tubes are readily accessible for cleaning purposes. With the heat-exchanger, the pressure drop required to give turbulent flow is low, and optimum velocity of flow past the tubes can be readily obtained. As the heat-exchange tubes are preferably vertical, the exchanger is eminently suitable for evaporation or condensation purposes, such as occurs in refrigeration circuits, the evaporating or condensing fluid passing through the heat-exchange tubes.

In an experiment conducted under identical conditions using a heat-exchanger of the present invention and a vertical shell and tube heat-exchanger for cooling water, it was found that the heat-exchanger of the present invention had a heat-exchange co-efficient which was some 33% greater than that of the vertical shell and tube heat-exchanger.

WHAT WE CLAIM IS:—

1. A heat-exchanger comprising one or more inter-connected heat-exchange elements, wherein the element or battery of elements comprises two flat, rectangular side plates, spaced part from one another, and heat-exchange tubes extending between the plates from a first header, or battery of headers, disposed along one pair of adjacent edges of the side plates, to a second header, or battery of headers, disposed along the opposite pair of adjacent edges of the side plates, the headers and tubes constituting a flow path for one heat-exchange fluid, each header including a channel-section header member, the heat-exchange tubes being entered into holes in the webs of the channel-section header members, the flanges of each header member being held between the side plates, and there being an inlet and an outlet to the space between the plates which space constitutes a flow path for another heat-exchange fluid.

2. A heat-exchanger as claimed in Claim 1, wherein two channel-section side members are provided one along each remaining pair of adjacent edges of the side plates, the flanges of said channel-section side members being held between the side plates, one, or each, such side member being apertured to provide said inlet and outlet.

3. A heat-exchanger as claimed in Claim 2, wherein said side members are held in position by bolts or the like passing through apertures formed in the flanges of the side members and registering apertures formed in a marginal side portion of the side plates.

4. A heat-exchanger as claimed in Claim 1, 2 or 3, wherein the flanges of each header member are secured in a fluid-tight manner to the walls of a tube formed with an axially extending cut-out in that region of the tube to which the header member is secured, the tubes constituting an inlet or outlet respectively for said one heat-exchange fluid.

5. A heat-exchanger as claimed in any one of the preceding claims, wherein the flanges of each channel-section header member protrude beyond the edges of the side plates, and wherein a plate is detachably secured over said flanges, the arrangement being such that said plates can be readily removed to facilitate cleaning of the tubes.

6. A heat-exchanger as claimed in any preceding claim, wherein the space between the side plates is sub-divided by one or more baffles, staggered so as to provide a number of passes for said other heat-exchange fluid.

7. A heat-exchanger as claimed in Claim 6, wherein each baffle is substantially channel-shaped, but has angles between the web and the flanges thereof, of slightly more than 90°,

the arrangement being such that the flanges press with deformation against each other and/or the side plates and are displaced to a position where they are perpendicular to the web, the baffles being thereby held in position.

8. A heat-exchanger as claimed in Claim 6, wherein each baffle comprises a plate having members of rubber or like resilient material at each side thereof, the members pressing with deformation against each other, and/or the side plates, and providing a fluid-tight seal between the spaces above and below the baffle(s), whereby the other heat-exchange fluid is constrained to follow a path substantially parallel to the baffle(s).

9. A heat-exchanger as claimed in any preceding claim, wherein the side plates are strengthened by spiders held in position by bolts or the like passing in fluid-tight manner through the side plates.

10. A modification of a heat-exchanger as claimed in Claim 1, wherein the side plates are tubular and co-axial, and enclose an annular space in which the heat-exchange tubes extend with their axes parallel to that of the tubular plates, the headers also being of annular construction.

11. A heat-exchanger comprising one or more inter-connected heat-exchangers, substantially as hereinbefore described with reference to Figures 1 to 3 of the accompanying drawings, with or without either of the modifications shown in Figures 4 and 5, and Figure 6 of the accompanying drawings.

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Agents for the Applicant.

PROVISIONAL SPECIFICATION

Improvements in or relating to Heat-Exchangers

We, XFLO HEAT EXCHANGERS LIMITED, a British Company, of 139, Temple Chambers, Temple Avenue, London, E.C.4, do hereby declare this invention to be described in the following statement:—

This invention relates to heat exchangers.

According to the invention there is provided a heat exchanger comprising one or more inter-connected heat exchange cells, the cell or a battery of such cells comprising two rectangular side plates spaced apart from one another and heat exchange tubes extending between the plates from a first header or battery of headers to a second header or battery of headers, the headers and tubes constituting a flow path for one heat exchange fluid, there being means holding the plates in their spaced relation and providing an inlet and an outlet to the space between the plates, which space constitutes a flow path for another heat exchange fluid.

For a better understanding of the invention one constructional form thereof will now be described by way of example.

In this constructional form, the heat exchanger comprise two rectangular side plates spaced apart from one another and straight tubes extending between the plates as between a top header and a bottom header, the headers and tubes constituting the flow path for the one heat exchange fluid, and the space between the tubes and the side plates constituting the flow path for the other heat exchange fluid.

The side plates are $\frac{1}{4}$" thick mild steel, and are held in their spaced parallel relation by means of two channel-section side members, the flanges of which are formed with holes for registering with corresponding holes formed in marginal side portions of the side plates, the channel-section side members and the side plates being secured together by bolts passing through the registering apertures. The web of one of the side members is formed with two apertures which are located one near each end of the member, two flanged pipes being connected to the side member in such a way that the pipes communicate with the space between the side plates through a respective one of each such apertures, thereby constituting an inlet and an outlet for the other heat exchange fluid.

The top and bottom headers are identical, and it will suffice to describe one such header. The header consists of a drawn mild steel pipe of greater length than the breadth of the side plates, the pipe having a flanged connection at one end, and being sealed at the other end. An axially extending cut-out is formed in the pipe intermediate its ends, the cut-out extending for substantially the breadth of the side plates, and a channel-section header member is disposed around the cut-out with the flanges of the member secured to the walls of the pipe, there being bridge-shaped end plates secured one at each end of the member for ensuring a fluid tight connection between the member and the pipe. The flanges of the channel-section header member are formed with registering holes, and tubes extend one between each hole of one flange to a registering hole of the other flange, the holes being formed to register with corresponding holes formed in marginal end portions of the side plates and the header being secured to the side plates by bolts passing through the registering holes and tubes.

The web of the channel-section header

member is formed with a plurality of staggered apertures into each one of which a drawn, mild steel, heat exchange tube is entered, each such tube being either welded or expanded into position. The tubes are entered at each end into one of the headers, and extend between the side plates, the headers constituting an inlet and an outlet for the one heat exchange fluid.

In order to prevent the side plates buckling outwardly under the influence of heat and/or pressure, registering holes are fromed in the plates. A spacing tube extends between each pair of registering holes, and a bolt passes through each tube and its associated holes, the heads of the bolts and the nuts bearing against the plates by means of washers so as to ensure that heat exchange fluid is not able to escape past the bolts. The registering holes in the side plates are arranged in vertical rows, and, because of the spacing tubes, the heat exchange tubes have to be arranged in groups.

The space between the heat exchange tubes and the side plates is subdivided by a plurality of horizontal baffles, staggered so as to provide a number of passes for the other heat exchange fluid. Each baffle is of substantially channel shape, but the angles between the web and the flanges are slightly more than 90°, so that when the side plates are brought together the flanges are displaced to a position where they are perpendicular to the web, the baffles being thereby held firmly in position. Each baffle extends for a major portion of the breadth of the side plates and is apertured to receive the heat exchange tubes which pass through the baffle.

The headers are arranged with their inlet or outlet at one side of the exchanger so that the exchanger has but one tube pass. However, by arranging the headers with the inlet and outlet at opposite sides of the exchanger it is possible to provide a plurality of tube passes by positioning appropriate baffles in the headers.

The heat exchanger just deschibed may be used by itself, or may constitute one cell of a composite heat exchanger which consists of a plurality of such cells appropriately interconnected to form a battery, thus giving, in effect, a plurality of passes both inside and outside of the tubes. In the latter case, the cells are also connected together side by side by means of long bolts passing through the spacing tubes of each exchanger.

Due to its construction, the heat exchanger lends itself to economical and mass production, and for a given duty takes up less floor or packing space than an equivalent conventional heat exchanger. Also, the tubes are readily accessible for cleaning purposes. With the heat exchanger, the pressure drop required to give turbulent flow is low, and optimum velocity of flow past the tubes can be readily obtained. As the heat exchange tubes are preferably vertical, the exchanger is eminently suitable for evaporation or condensation purposes, such as occurs in refrigeration circuits, the evaporating or condensing fluid passing through the heat exchange tubes.

It will be appreciated that many modifications of the heat exchanger are possible, including increasing the external or internal surface area of the tubes by finning, and making one of the headers of a floating head construction. Where the exchanger is to be subjected to high internal pressures, it is possible to strengthen the side plates by means of external spiders held in position by the bolts passing through the spacing tubes. Also, it is possible to make the heat exchanger in annular form where it is to be subjected to high internal pressures, the side plates being bent to enclose an annular space within which the tubes are disposed, the headers likewise being annular.

As a further modification, the headers can include detachable covers which are held in position by means of bolts passing through the tubes. The covers are so arranged as to be readily removable, and to provide easy access to the tubes, whereby cleaning of the tubes is facilitated.

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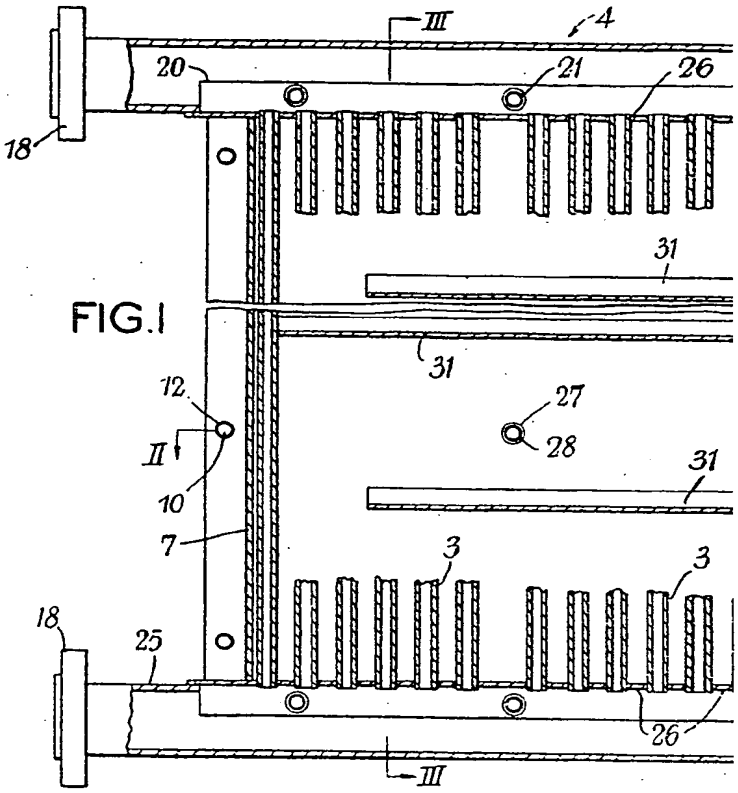
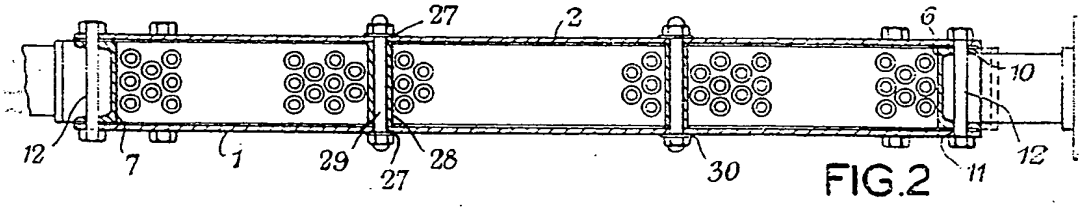

III
4
20
21
26
18
31
31
12
27
28
II
10
31
7
3
3
18
25
26
III

FIG.1


27
2
6
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12
12
7
1
29
27
28
30
11

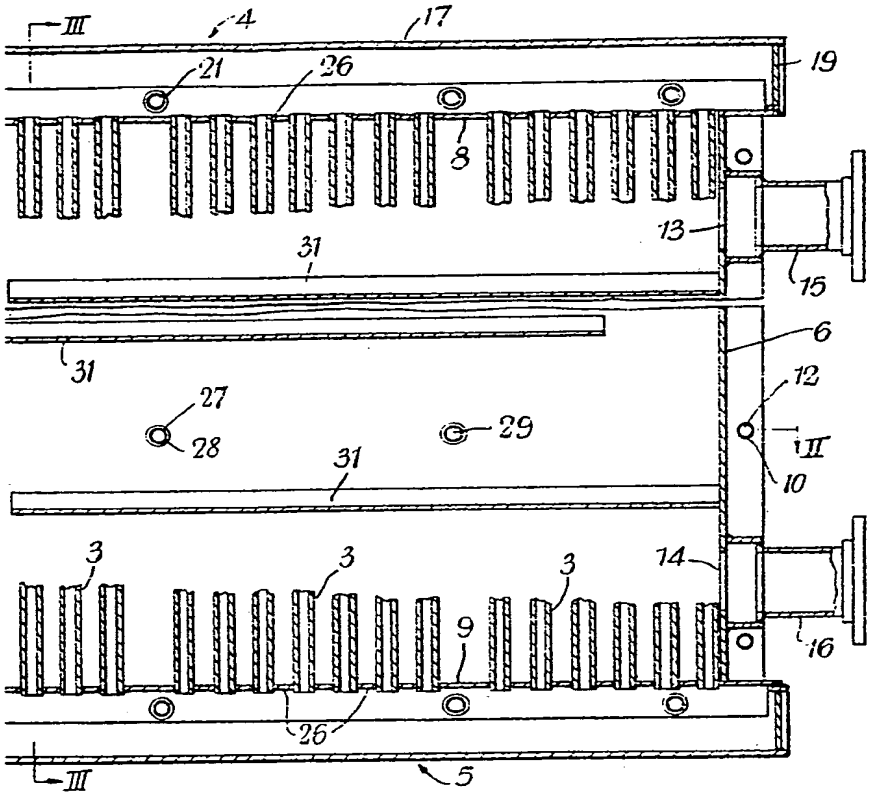
FIG.2

841,951 COMPLETE SPECIFICATION

2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEET 1



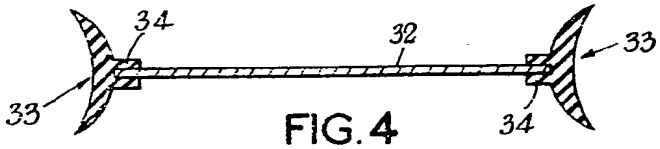


FIG.4

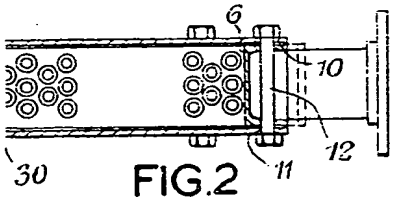


FIG.2

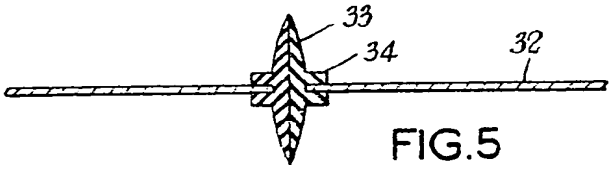


FIG.5

841,951 COMPLETE SPECIFICATION

2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

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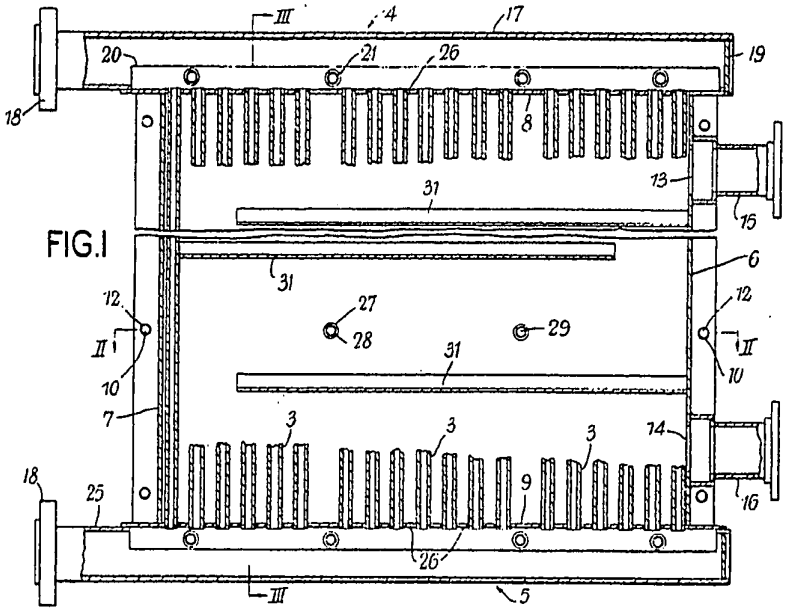

FIG.1

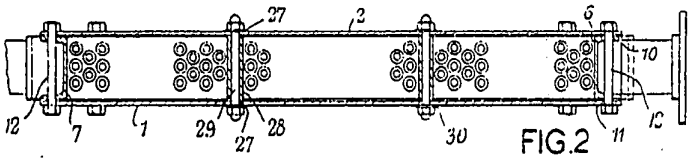

FIG.2

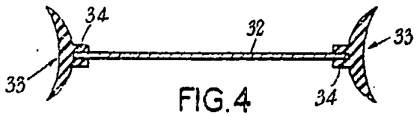

FIG.4

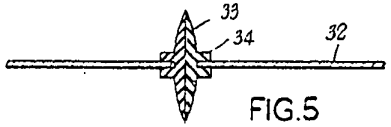

FIG.5

841,951 COMPLETE SPECIFICATION
2 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 2

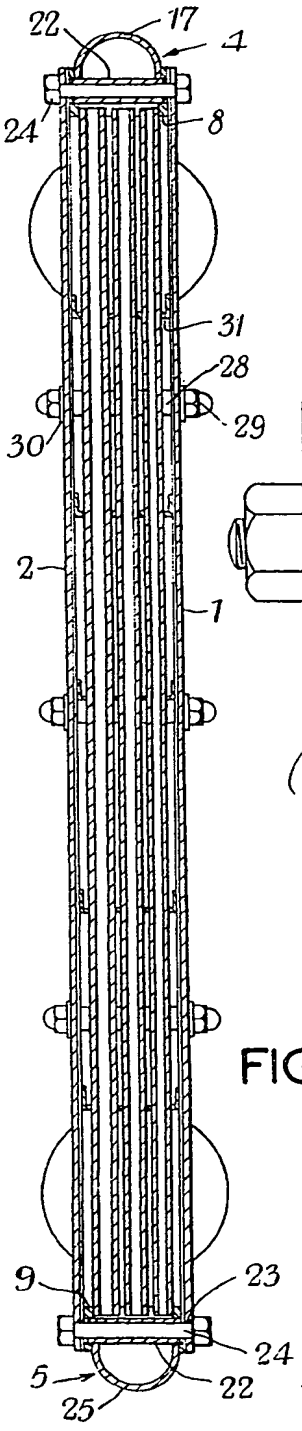

FIG.3

FIG.6